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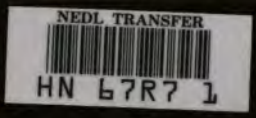

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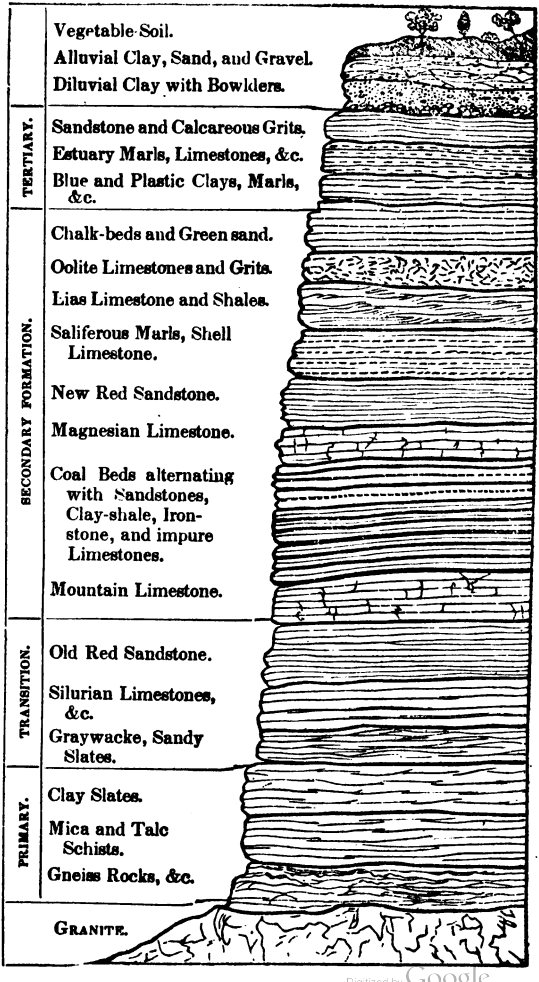

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THE

MINER'S GUIDE,

AND

METALLURGIST'S DIRECTORY.

"The small taper which gives us light to read by, is preferable to the blazing meteor of the sky, which raises astonishment, but soon leaves us in darkness."

BY J. W. ORTON.

NEW YORK:
PUBLISHED BY A. S. BARNES & CO.
CINCINNATI:—H. W. DERBY & CO.
1849.

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PREFACE.

THIS Work is intended—

1. To furnish those who have not the advantage of a large library, with the substance of the researches of eminent miners and metallurgists, and to explain many processes and technical terms and phrases which are frequently not understood.

2. To form a portable book of reference for those who wish to acquire an additional knowledge of those arts,—a repertory of every thing needful for the acquisition of a knowledge of the applications of geological science to purposes of utility.

3. To be a companion to the practical miner and metallurgist—an invaluable *vade mecum*. To enable the latter to extract, to assay, and to tell the properties of all the useful metals;

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and to acquaint the former with a knowledge of rocks and their order of superposition, by which great assistance in searching for the metals may be derived, and which will give him a clue to the rich depositories of mineral treasures.

NOTE.—As an invaluable companion of the present work, the Author would recommend "*Elements of Geology, by D. Page*;"—a volume of superior merit from Chambers' Educational Course.

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MANUAL

OF

MINING AND METALLURGY.

INTRODUCTION.

An acquaintance with the general results, collected and classified by geology, must be our first guide in the investigation of mines. This enables the observer to judge whether any particular district should, from the nature and arrangement of its rocks, be susceptible of including within its bosom, beds of workable and valuable ores. It indicates, also, to a certain degree, what substances may probably be met with in a given series of rocks, and what locality these substances will preferably affect. For want of a knowledge of these facts, many persons have gone blindly into researches equally absurd and ruinous; and an amount of money much greater than is generally known has thus been expended in vain. To attempt any thing without it, would be like sending a ship to sea without a helm to direct its course, without sails to catch the impelling breezes, and

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without a compass to guide its way. Formerly, indications of mines were taken from very unimportant circumstances, but geognostic observation has substituted more rational characters of metallic deposites. They may be called—

1. *Negative* indications, which are derived from that peculiar geological constitution, which, from experience, or general principles, excludes certain metallic matters; e. g., granite, and, in general, every primitive formation, forbids the hope of ever finding within them combustible fossils such as pit-coal, unless it be beds of anthracite: there, also, it would be vain to seek for common salt. Granite rocks very seldom include silver; or limestone, ores of tin. Volcanic territories never afford any metallic ores worth the working; nor do extensive veins usually run into secondary and alluvial formations. The richest ores of iron do not occur in secondary strata; and the ores of this metal, peculiar to these localities, do not exist among primary rocks.

2. *Positive* indications, which consist either in an efflorescence of the subjacent metallic masses: as magnetic attraction, for iron ores; bituminous stone or inflammable gas, for pit-coal; the frequent occurrence of fragments of particular ores, etc.; or, in the geological epoch and nature of the rocks. Marks of this kind acquire new importance, when, in a district susceptible of including deposites of workable ores, the vein-stones are met with which

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usually accompany any particular metal. The general aspect of mountains, whose flanks present gentle and continuous slopes, the frequency of sterile veins, the presence of metalliferous sands, the neighborhood of some known locality of an ore, as ironstone, in reference to coal; lastly, the existence of salt springs and mineral waters, may furnish indications.

Classification of Rocks.—To understand the relation which geology bears to mining, and the way in which it can be made subservient to its promotion, it is necessary to glance at some of the revelations which the science has made in regard to the structure and present condition of our globe, and the order in which the materials are arranged.

When a rock is divided into layers by seams, it is said to be *stratified* or divided into *strata*—each of these layers is called a *stratum*. When one mass of rock is contained in another, it is said to be *imbedded* or to occur in a *bed*. The inclination or general direction of the strata is called the *dip*. This is an important point to ascertain. *Formation* is used to signify a mass of mineral substances formed by the same agent, under the same circumstances, and at the same time.

Suppose ourselves to have arrived upon a large and extensive plain, which skirts the base of an elevated mountainous district, and begin a perpendicular excavation into the earth, we shall pass through the different classes of rocks in the following order :—

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For nearly 100 feet we shall pass through layers of loam, clay, sand, and fine gravel. This deposite, from an existing river, is denominated *alluvium*, which is the soil and earth which rests upon the rocks. Having penetrated this, we shall find ourselves upon the second formation, called *drift* or *diluvium*. This is composed of coarse sand and gravel, with fine sand, containing large rounded masses of rock called bowlders. The third series of strata which we shall penetrate, is composed of layers of clay, sand, gravel, and marl, with occasional beds of quartz and limestone. They contain many petrifactions, and are usually horizontal. They are called *tertiary*. After passing through these, we come to the *secondary*, composed for the most part of solid rock, mostly made up of sand, clay, and pebbles, cemented together. With these we find many remains of animals and plants, graywacke, limestone, sandstone, coal, lias, clay, marl, green sand, and chalk. Below this are the *primary rocks*. They are destitute of organic remains, have a structure always crystalline, and are more highly inclined. Here occur granite, gneiss, mica slate, limestone, gypsum, talcose slate, hornblende slate, quartz rocks, and clay slate.

Veins.—These are seams, or tabular-shaped masses, that almost always traverse the direction of the strata, and are composed of materials that differ from those of the rocks which they intersect.

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They vary much in their magnitude, yet the length and depth always bear a certain proportion to each other, and the breadth to the length and depth. The length and depth are frequently nearly alike. Few metalliferous veins reach above 1800 feet in depth, or 1200 feet below the surface of the mountains in which they are situated. In general, veins continue in one direction, and are usually much inclined, always more so than beds. The metallic matter called *ore* rarely occupies the whole of the vein; but is disseminated through the quartz, sulphate of baryta, wacke, granite, etc., which constitutes the greater part of the vein, and is called the *gangue, matrix,* or *veinstone.* Metallic veins are most numerous in primary and secondary rocks. They occur more frequently in flat hilly country than in steep mountainous country, and generally on the ridges of the hills. Beds, on the contrary, are more abundant in steep and mountainous country. As a general fact, the veins are seldom rich near the surface; but increase in value at a medium depth, and grow poor again at a greater. They are most productive near the junction of stratified and unstratified rocks. Their productiveness also depends on their direction somewhat; an east and west direction being regarded in some mines as the most favorable, while the north and south veins are usually unproductive. Great metalliferous veins usually run parallel with the general direction of great valleys.

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Of the instruments and processes of subterranean operations.—It is by the aid of geometry, in the first place, that the miner studies the situation of the mineral deposites, on the surface and in the interior of the ground, determines the several relations of the veins and rocks, and becomes capable of directing the perforations towards a suitable end. The instruments are: 1. The *magnetic compass*, which is employed to measure the direction of a metallic ore, wherever the neighborhood of iron does not interfere with its functions. 2. The *graduated semicircle* or *clinometer*, which serves to measure the inclination. 3. The *cord* or *chain*, for measuring the distance of one point from another. 4. When the neighborhood of iron renders the compass uncertain, a *plane table* or *plate* is employed.

Means of penetrating into the interior of the earth.—1. Manual tools; 2. Gunpowder; and 3. Fire. The *pick* is a light tool used for digging or removing in small quantities. One side is used as a hammer; the point is of steel, carefully tempered. The *gad* is a punch or wedge of steel, with a wooden handle, driven into small openings of rocks. The *shovel* has a pointed form, to enable it to penetrate among the coarse and hard fragments of the mine rubbish. The blasting or shooting tools are, a *mallet, borer, claying-bar, needle* or *nail, scraper, tamping-bar*. The borer is an iron bar, tipped with steel, formed like a thick chisel. A hole being

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bored, a cartridge is enclosed in it, furnished with a stem or tube, through which the powder may be inflamed. Any soft species of rock, free from flinty particles, is used for cramming the hole, and is rammed by the tamping-bar. Each hole bored in a mine should be so placed, in reference to the schistose structure of the rock, and to its natural fissures, as to attack and blow up the least-resisting masses. The quantity of gunpowder should be merely sufficient to split it. In certain rocks and ores of extreme hardness, the action of fire is used with advantage, to diminish the cohesion of the rock.

When the existence of a deposite of ore is merely suspected, without positive proofs, recourse must be had to labors of research, in order to ascertain the richness, nature, and disposition of a supposed mine. *Subterranean workings* afford the most satisfactory knowledge. They are executed, 1. By longitudinal galleries, hollowed out of the mass of the beds or veins themselves, in following their course; 2. By transverse galleries, pushed at right angles to the direction of the veins; 3. By inclined shafts, which pursue the slope of the deposites, and are excavated in their mass; 4. By perpendicular pits. If a vein or bed unveils itself on the flank of a mountain, it may be explored, according to the greater or less slope of its inclination, either by a longitudinal gallery, opened in its mass from

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the outcropping surface, or by a transverse gallery falling upon it in a certain point, from which either an oblong gallery or a sloping shaft may be opened.*

Metallic ores occur in four modes: 1. In regular interstratified layers or beds. 2. In veins or fissures crossing the strata, and filled with the ore united with some matrix. 3. In irregular masses. 4. Disseminated in small fragments through the rocks.

* Dr. Ure.

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METALS,

THEIR CHEMISTRY AND GEOLOGY.

General Properties.—A metal is a body which conducts electricity and heat, which is opaque, and has a high and peculiar brilliancy known as the metallic lustre.

Extraction.—Metals are seldom found naturally in their metallic form. When they so occur, they are said to be in a *native* state. Their characters are generally masked under some form of combination with oxygen or sulphur, and are then said to be in the state of *ore.* They are met with, generally, in veins penetrating the strata, intermixed with various earthy substances. To separate the metal, after it is dug from the mine, the mass is broken up, and subjected to the operations of sorting, stamping, washing, roasting, smelting, and refining. Under each metal will be included the method of reducing its ores.

Assaying.—This is the determination of the quantity of any particular ore, to discover whether it will be worth while to extract it largely, and in what manner the process is to be conducted. The

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knowledge requisite for this is called the *docimastic art.*

1.—Gold.

Geognostic situation.—This metal has hitherto been found only in the metallic state, either pure or in combination with other metals. It occurs in veins, and disseminated in primary and secondary rocks, and abundantly in alluvium or drift which constitute certain plains, and margins of rivers. The rocks in which it most often occurs, are granite, quartz, slate, hornstone, sandstone, limestone, clay-slate, gneiss, mica-slate, and especially in talcose slate, and rarely in graywacke and tertiary strata, but never in serpentine. It also occurs in veins of iron ore, antimony, zinc, lead, barytes, etc. When the metal exists in the bosom of primary rocks, it is particularly in schists. The gold of commerce is almost exclusively found in alluvial deposites, where it occurs in small particles, or grains called *gold dust,* mingled with sand and debris. It sometimes occurs in beds or layers, instead of veins which conform to the regular structure of the slaty rocks. It is usually found alloyed with small portions of other metals, particularly silver and copper.

Extraction.—When native gold is found in a state of mixture with foreign matters, its extraction is commonly performed by amalgamation with

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quicksilver. The whole of the matter procured from the vein is collected and broken into pieces about the size of a nut, which are arranged into heaps according to their richness. The quantities thus procured are afterwards freed from most of the stony matter mixed with it, by pounding and washing. They are then reduced to powder, and made into a thick paste with salt and water. Quicksilver is now squeezed through a leather bag on the mixture, and as the metal flows in in minute globules, it is intimately blended with it by means of wooden spatulas. When the requisite quantity of mercury is added, the whole is beaten together, and kept for two or three days at about the temperature of boiling water, by which means the union of the metals is promoted. The earthy matter is then carried off by washing or levigation, and most of the mercury removed by squeezing the remainder through a leather bag. The residue is subjected to distillation or heat only, by which the mercury is expelled, and the gold obtained, alloyed perhaps with a little silver. (See *Silver*.) When the gold is contained in other ores, the metallic are first separated from the earthy substances. For doing this, the ore is reduced to a powder in *stamping-mills*. This mill consists of a cistern through which water flows, and heavy beams of wood terminated below by iron, and moved upwards and downwards. The powder is carried off

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by the stream into vessels, where it is deposited: the heaviest being deposited nearest the cistern. The vessels are of different sizes;—that nearest the cistern being about twelve feet long and nine inches in breadth, and as many deep. The others gradually enlarge as they retire. They also vary in their inclination,—the first having a slope of about three inches, the second about one inch, the third and fourth about half an inch, and the fifth and sixth being level. Each vessel is furnished with a groove at the extremity farthest from the cistern, into which pieces of wood are placed, varying in height according to the quantity of ore collected in the vessel, and each vessel communicates with that beyond it. When the water flows from the mill into the first vessel, the heavy part of the ore is deposited and collected where the wood is put into the groove; as the powder reaches the top of this another piece is put over the former, and so on till the vessel is nearly filled; then the water is allowed to flow into the second vessel, and from this, when full, into the third. The particles of ore thus procured are still farther freed from impurities by washing. Each parcel is put into a wicker basket, into which a stream of water flows, and is received on inclined tables, grooved in various directions. If the gold thus procured is mixed only with earthy matter, it is triturated with quicksilver, as before described; or fused in crucibles with some flux, as

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nitre or pearlash. If, however, it contains inflammable matter, as sulphur, it is roasted. Lime and lead ore are mixed with it in quantity proportionate to the gold, and kept at a red heat till part of the sulphur is driven off. Increase the heat until the whole melts, after which pour it into moulds of sand. By repeated fusions the gold is obtained alloyed only with silver, copper, and lead, from which it is freed by *refining*, or *cupellation*.

The impure gold is melted with two or three times its weight of lead, and exposed to heat on a cupel under a muffle, or on a hearth of a refining furnace. When the greater part of the foreign metals is abstracted, the remaining fused metal will, if the process is completed, exhibit various colors, and at length suddenly brighten, and its surface become highly luminous. The metal is detached while hot. The gold, even after this process, may be alloyed with a little silver; it is therefore subjected to the operation of *parting*. The principal agents employed in this process are, nitric acid, marine acid, and sulphur. Parting by the first is most convenient, and most used. It is called simply *parting*. That made by marine acid is by cementation, and is called *centrated parting*. Parting by sulphur is made by fusion, and is called *dry parting*.

Parting by Nitric Acid. —The first step employed is quartation, which consists in fusing three parts of

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silver with one of the gold, for to ensure success, the silver must be to the gold as 3 to 1. The alloy must next be granulated, by melting it in a crucible, pouring it into cold water and stirring it briskly. It is then put into vessels of a pear-shape, about twelve inches long and seven wide at the bottom, with twice its weight of nitric acid, (aquafortis.) The vessels are then gently heated on a sand-bath, and when the action has ceased, the liquor is to be poured off and more acid added. The gold left is washed with tepid water, until the liquor which comes off does not stain a piece of copper. It is then fused in a crucible with borax and nitre. The silver in the liquor may be recovered by putting in a piece of pure copper.

Centrated Parting, or Cementation.—The alloy is first beaten into thin plates, and placed in alternate layers in a pot, with a cement composed of four parts of bricks powdered and sifted; of one part of copperas calcined till it becomes red; and of one part of common salt: this is made into a thick paste with a little water. The whole is covered with a lid and luted, and then exposed to heat, until a great part of the alloying metals are removed. This will take twenty-four hours, but the heat must not be raised so as to melt the gold. If it is not sufficiently pure, it is cemented a second time. This process is chiefly used to extract silver from the surface of gold.

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Dry Parting, or Fusion.—The alloy is first melted and granulated. About seven-eighths of it are then mixed with about one-eighth of the flowers of sulphur, and the mixture heated in a covered crucible, first slowly, and afterwards till the whole is brought into fusion, in which state it is kept on the fire for an hour; one-third of the alloy reserved is then added and thoroughly stirred with it by means of a wooden rod, and the whole is again heated for about an hour. Another third of the alloy is then mixed with it, and after a similar operation, the remainder is added, and the mixture kept fused for three hours, during which it is frequently stirred. When the surface has become quite white, it is then poured into greased cones. When cold, the upper part will be found to be sulphuret of silver, and the lower a metallic button composed of gold and silver. If the former contain gold, it must be heated in an open crucible. The metal is repeatedly subjected to the same process; and the gold is thus concentrated into a smaller part, so that it may be parted by aquafortis without too much expense.

When the gold is found mixed with sand or gravel only, it may be separated by *washing;* a process, in which advantage is taken of the difference of specific gravity. It is sometimes performed by hand, in wooden vessels or troughs, which cross a current of water; and sometimes, if

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the ore is rich and valuable, upon inclined tables, covered with cloth. The metal sinks first, while the stony matter, which is lighter, is carried farther down the current. A decided improvement on this has been made by a European, and patented in 1844. In this process the gold with its impurities, is subjected to the combined action of two currents of water—one vertical and the other horizontal; the former carrying the impurities above the level of the metallic particles, and the latter washing them away. The apparatus consists of a series of sieves separated by partitions, and surrounded by a casing with a valve opening upwards, and placed at one end of the series. The materials are dropped into the first sieve of the series from the hopper above, adapted to the delivery in given quantities, and the sieves then receive a vertical reciprocating movement in a water-tank. On the descent of the sieves, the water passes through the meshes of the sieves and the valve; the former producing the vertical current, loosening the lighter and impure particles, and carrying them above the partitions; and the latter, the horizontal current, washing all that has been carried above the partitions to the next sieve, and so on to the end of the series, to catch the particles of gold that may have been carried up with the impurities.

Assaying.—Reduce the ore to powder, mix it with four parts, by weight, of dry caustic potash

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and one of fused borax, and subject it to heat in a silver crucible. When fused, pour it out, and if any remains in the vessel, remove it by muriatic acid. Digest this with the fused matter reduced to powder in muriatic acid, to which from time to time add a little nitric acid. When the action ceases, pour off the solution, and wash well with water the residue, the washings being mixed with the solution. To the solution, add copperas until no precipitate falls; wash the precipitate and fuse it in a crucible with half its weight of nitre and a little borax, when a button of pure gold will be found at the bottom.

Iron pyrites containing gold is analyzed by digesting the ore in muriatic acid, with the addition of a little aquafortis. What is left is roasted to drive off the sulphur, and again digested in acid. The solutions obtained must be neutralized by potash, and proto-nitrate of mercury is added. The precipitate thrown down is then fused with nitre, by which the gold is procured. If there be silver in the ore, it is obtained by treating that part of it not acted upon by the acid, with caustic, potash, and muriatic acid. Lead ore containing gold is analyzed by digesting it in aqua regia, evaporating the solution, and then adding proto-nitrate of mercury. The part insoluble, when treated as above, will yield the silver in a pure state.

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The assay of the alloys of gold will be treated under article *Silver*.

The process of assaying in the *dry way* consists in melting the gold with lead in a cupel, when the lead, combining with the other metals the gold contained, sinks into the substance of the cupel, leaving the gold on the surface. Gold dust is thus assayed.

External Characters.—Color, golden or orange yellow, passing into grayish yellow; in some varieties inclines to brass-yellow. Seldom occurs massive, often disseminated, capillary, amorphous dentritic, and crystallized, in cubes, octohedrons, rhomboidal dodecahedrons, and tetrahedrons. Internally, shining, glistening, and metallic. Fracture, hackly. Tessular. No cleavage. Soft, malleable, ductile, tenacious. Specific gravity = 19.26 to 19.5.

Chemical Characters.—Unaltered by exposure to air, moisture, or acids. Soluble in aqua regia. Fusible with the blowpipe. Melts at 2016° Fahrenheit.

Distinctive Characters.—Gold is the only metal which has a yellow color. Its malleability will distinguish it from iron and copper pyrites, and from yellow mica, for each of which it is often foolishly mistaken.

The gold of Africa is often adulterated with these pyrites and brass-filings. This fraud may

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easily be detected, by throwing the dust into aqua-fortis, which dissolves the substances and leaves the gold untouched.

2.—Platinum.

Geognostic Situation.—This metal occurs only in the metallic state, associated or combined with various metals, as copper, iron, lead, gold, silver. It is frequently disseminated in rocks of igneous origin, as the primary. It is often found in sienite, associated with gold. But it occurs principally in alluvium or drift.

Extraction.—The grains must be first spread on a table, and a current of air from a bellows passed obliquely over them. By this the lighter particles, as quartz and iron ore, are removed. The crude metal is then dissolved in aqua regia, and a solution of sal-ammoniac added. The precipitate is then exposed to heat. The fine powder thus obtained is subjected to violent pressure in a brass tube. It is then heated to the highest temperature of a smith's forge, and carefully hammered. After this operation, it is coated with a reddish crust, which is removed by covering it with borax, and exposing it to a white heat; it is then washed with muriatic acid, which leaves the metal resplendent.

Sometimes the grains contain a little gold. This

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may be separated by dissolving them in aqua regia. To the solution add copperas, and fuse the precipitate with nitre and borax.

Assaying.—Digest in a retort 100 grains with ten times its weight of aqua regia; apply the heat of a lamp till half of the acid passes over into the receiver; decant the fluid remaining, and repeat the process with more acid. Filter. To the solution add a solution of sal-ammoniac; wash and dry the precipitate. Heat in a crucible until all fumes cease. The weight of the spongy mass will show the percentage of the metal.

External Characters.—Color, very light steel-gray, approaching to silver white. Occurs in grains and rolled pieces, seldom larger than a pea, and resembling coarse iron-filings. Roundish. Shining and glistening. Streak unchanged. Hardness nearly equal to that of iron. Malleable; ductile. Structure sometimes lameller, but often not obvious. Specific gravity = 20.98.

Chemical Characters.—Infusible in the hottest furnaces, but melts before the compound blowpipe. Unaltered by exposure to air, moisture, or acids. Dissolves in aqua regia.

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3.—Silver.

Geognostic Situation.—This metal is found mostly in primary and secondary slates. It is found native, also combined with sulphur and muriatic acid. It likewise occurs in the metallic state, mixed with copper, antimony, lead, arsenic, gold. The rocks richest in it are gneiss, mica-slate, clay-slate, graywacke.

Extraction.—Silver is extracted from its ores by amalgamation and fusion. The first process is followed when the ore is rich in silver, the latter when it contains little.

Amalgamation.—The ore, being freed as much as possible from its stony ingredients, is mixed with common salt, in the proportion of nine to ten per cent. It is then exposed for some hours on the floor of a reverberatory, till the vapor ceases to come off; the mixture being frequently stirred. When the matter is cold it is reduced to powder in a mill, and mixed with an equal quantity of quicksilver. The amalgamation may be performed in barrels, which are made to revolve. The mixture being put into these vessels it is made into a thick paste with water, and kept agitated for about forty-eight hours; and when the amalgam has fallen to the bottom, it is withdrawn through an aperture. The remainder is then washed to get more of the amal-

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gam, and the residual matter roasted with about three per cent. of sulphur, and subjected to a similar process. The amalgam is squeezed in a leather bag to remove the superfluous mercury, and then subjected to distillation.

Fusion.—The ore generally subjected to this process is lead glance. It is first subjected to stamping and washing. Then roasted in a reverberatory, the heat not being raised so much as to melt it; and when it begins to adhere together on its surface, it must be well stirred. In five or six hours the flame changes from blue to white; charcoal in powder is then thrown in, by which part of the lead collects at the bottom: when enough is formed, quicksilver is mixed with the scoria to thicken it, and the fused metal is drawn off. After this the heat is continued, and the metal is taken out as it is formed, the temperature being increased. The metal, as it is collected, is covered with charcoal, and the scoria removed. It is then covered with sawdust, pieces of wood, and a little resin, and constantly stirred. When the flame ceases it is poured into moulds. It is then subjected to *cupellation*, as described under article *Gold*.

When the ore contains copper, it is mixed with another ore containing silver, iron, and sulphur, and with the scoria of a former process. The mixture is fused in a blast furnace. The matter, during cooling, separates; that below is roasted to expel

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the sulphur and arsenic, and to rust the iron. It is then mixed with one and a half of rich ore and some scoria, and is fused. The metallic matter obtained is again roasted, and fused with about one half of litharge and as much scoria. When cold it separates into three parts; the second, containing copper and silver, is melted with lead and copper scoria, and afterwards with litharge and scoria. If it is not pure, then it must be repeatedly fused.

Assaying.—The method of examining the purity of silver is by mixing with lead, and is the same as cupellation. The ore must first be roasted, and then mixed with litharge, and quickly fused. The product is then fused with black flux; the metallic button which falls is mixed with the proper quantity of lead, and placed in the cupel.

Assay of Gold alloyed with Silver.—The alloy being mixed with the due proportions of lead and silver, (the latter amounting to three times the quantity of gold,) is placed in a muffle, and the cupellation performed as above. When the process is finished, the button of metal is taken out, and kept in a state of fusion in a crucible for some time, by which the lead is expelled. When cold, it is beaten into a plate, again made red-hot, and slowly cooled. It is afterwards extended into a thin leaf between steel rollers, and coiled loosely up, in which state it is submitted to the process of *parting*, described above. The quantity of lead added to

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the alloy should be forty parts to three of silver. In the cupellation there is little risk of making the heat too high.

The best mode of separating copper and silver, is to throw the article in a glazed earthenware dish, in which one pound of nitre is dissolved in nine pounds of oil of vitriol, with the aid of a little heat. The heat is then raised to about 200°. When the silver is dissolved the fluid is poured off, and the metal is precipitated by common salt, and obtained in the usual way; or the solution is diluted with water, and pieces of pure copper are immersed in it.

The forms in which silver occurs in nature, are:—

Native Silver.

Geognostic Situation.—Primitive and secondary rocks, with the ores of silver, copper, cobalt, etc. It often occurs penetrating crystals, or amorphous pieces of common quartz.

External Characters.—Color, silver white, often tarnished gray, or reddish. Occurs dentiform, capillary, ramose, reticulated, seldom massive, more frequently disseminated; also in plates and spangles, and crystallized in cubes, octohedrons, rhomboidal dodecahedrons, and tetrahedrons. Lustre, splendent to glimmering. Fracture, fine hackly. Specific gravity = 10 to 10.5.

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Chemical Characters.—Fusible into a globule. Melts at about 1873°, or a red heat. Soluble in aquafortis, forming the well-known *lunar caustic.*

Distinctive Characters.—Its color and malleability.

Composition.—Silver, with a little iron, antimony, copper, or arsenic.

Antimonial Silver.

Geognostic Situation.—In primary rocks, as granite and clay-slate, associated with the other ores of silver.

External Characters.—Color, silver or tin white. Occurs massive, in grains, and in cylinders, also in curved laminæ. Yields to the knife. Fracture, conchoidal. Specific gravity = 9 to 10.

Chemical Characters.—Fusible, with the emission of antimonial vapor, into a globule of silver.

Distinctive Characters.—Want of ductility; and the antimonial vapor; not giving a blue globule with borax.

Composition.—Silver 84; antimony 14.

Sulphuret of Silver.

Geognostic Situation.—Primary and secondary rocks, associated with the other ores of silver. It is an important ore for the extraction of the noble metal.

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External Characters.—Color, dark lead-gray, often with an iridiscent tarnish. Occurs in cubes and octohedrons; also reticulated, ramose, lamelliform, amorphous, and in plates. Cleavage imperfect. Fracture, flat conchoidal. Malleable. Easily sectile. Specific gravity = 7.

Chemical Characters.—Fusible with intumescence and odor of sulphur, leaving a globule of silver.

Distinctive Characters.—It may be distinguished from native silver by its less specific gravity, and its sulphurous odor under the blowpipe.

Composition.—Silver 85; sulphur 15.

Brittle Sulphuret of Silver.

Geognostic Situation.—Primary rocks, with the other ores of silver. It is a very rich ore.

External Characters.—Color, dark lead-gray, or bluish gray, passing into iron-black. Occurs massive and disseminated; also in hexahedral prisms. Lustre, metallic or dull. Structure foliated; crystals mostly intercept each other. Soft and brittle. Fracture, conchoidal. Specific gravity = 7.

Chemical Characters.—Fusible, with the evaporation of sulphur, arsenic, and antimony, into a globule of silver surrounded by a slag. Soluble in aquafortis.

Distinctive Characters.—It differs from *sulphuret of silver* in its want of malleability, and from other ores by its dark color and brittleness.

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Composition.—Silver 66.5; antimony 10; iron 5; sulphur 12; arsenic and sulphur 5.

Sulphureted Antimonial Silver. (Red silver.)

Geognostic Situation.—Primary rocks, chiefly in granite, mica-slate, and porphyry. It is a valuable ore.

External Characters.—Color, red of various shades, passing into lead-gray and grayish black; powder, crimson red. Occurs in masses and grains, also dentritic, membranous, capillary, and crystallized in hexahedral prisms, terminated by hexahedral pyramids; also in double six-sided pyramids. Lustre, metallic adamantine; crystals often striated. Structure imperfectly foliated. Yields to the knife. Translucent, opaque. Specific gravity = 5.20 to 6.68.

Chemical Characters.—Fusible, with antimonial fumes.

Distinctive Characters.—It differs from *sulphuret of arsenic* in having a greater specific gravity, and in leaving a globule of silver. *Sulphuret of mercury* is entirely dissipated by the blowpipe. The *sulphuret of silver* is malleable. *Specular oxide of iron* is magnetic after being submitted to the blowpipe, and the *red oxide of copper* is easily reduced to the metallic state by the blowpipe.

Composition.—Silver 60; antimony 20.3; sulphur 14.7; oxygen 5.

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Muriate of Silver. (Horn silver.)

Geognostic Situation.—Primary rocks, with the other ores. It is a good ore for the extraction of the precious metal.

External Characters.—Color, pearl-gray, greenish or reddish blue, yellowish or greenish white and brown. Occurs massive, investing other minerals, reniform, amorphous, and crystallized in cubes, octohedrons, and acicular prisms. Lustre, glistening and wavy. Soft, yields to the knife, and to pressure. Malleable. Feebly translucent. Becomes brown by exposure. Specific gravity = 5.5.

Chemical Characters.—Fusible in the flame of a candle. Before the blowpipe, emits muriatic acid fumes. Rubbed on moistened zinc, it leaves a film of silver.

Distinctive Characters.—*Muriate of mercury* is entirely volatile before the blowpipe, and does not leave a silver globule.

Composition.—Muriate of silver 88.7; oxide of iron 6; alumine 1.75; sulphuric acid (oil of vitriol) 0.25.

Tests for Silver.—Dissolve the metal in nitric acid, put in a quantity of potash or soda, and it will give a dark olive precipitate; put in a piece of copper, metallic silver will fall down; common salt gives a white precipitate, and galls a brown precipitate. Its solution is called *indelible ink.*

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4.—Mercury.

This metal is sometimes found in the native state, but the ore or source whence the greater portion is obtained is the

Sulphuret of Mercury. (Cinnabar.)

Geognostic Situation.—Occurs chiefly in new red sandstone; sometimes in a sort of mica-slate, limestone, gneiss, graywacke, beds of bituminous shale associated with black mineral resin, gray sandstone and limestone, clay, alluvium, and in rocks of the coal formation.

Extraction.—Mix the ore with its weight of lime or clean iron-filings, and put into iron retorts; and after a receiver containing some water is luted on, set them on sand-baths, and give them a sufficient degree of heat to force the mercury over.

Assaying.—Same as *Extraction*, which see. By this process 100 lbs. of ore yield from six to ten oz. of mercury.

External Characters.—Color, scarlet or carmine, passing into cochineal-red and lead-gray; sometimes with a tinge of yellow. Occurs massive, and crystallized in acute rhomboids; some varieties have a fibrous structure. Translucent, or opaque. Streak scarlet red. Lustre, adamantine, inclining to me-

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tallic; sometimes shining silky. Fracture, granular or fibrous. Sometimes occurs in thin plates or tabular crystals. Specific gravity = 8.

Chemical Characters.—Volatile before the blow-pipe, with the odor of sulphur.

Distinctive Characters.—From *sulphuret of arsenic, red silver ore, arseniate of cobalt,* and *red oxide of copper,* it is distinguished by its chemical character.

Composition.—Mercury 84.5; sulphur 14.75.

Tests for Mercury.—To a quantity of mercury dissolved in aquafortis, add fresh lime-water, the result = an orange precipitate; immerse a piece of copper, result = metallic mercury; immerse a plate of iron, result = a dark powder.

5.—Copper.

Geognostic Situation.—Occurs in veins, imbedded in various primary rocks, and as high in the secondary series as the new red sandstone; also in large blocks in alluvial districts; very rarely in tertiary rocks.

Extraction.—The oxides and carbonates of this metal are reduced by simply heating them with charcoal in a wind-furnace; but the sulphurets are reduced by a different and more difficult process.

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The ore is broken in pieces, and roasted in a furnace similar to a reverberatory, having a long chimney to increase the heat, and to carry off the sulphur and arsenic. The roasting takes about twelve hours, the ore being frequently stirred. It is then put into a smaller furnace, and brought to a state of fusion, occasionally mixing it with a little lime. The impurities which collect at the top are raked out. The melted metal is drawn out through a hole in the lower part of the furnace, which was stopped by clay mixed with a little coal. The copper is conveyed into vessels suspended in a well, through which a stream of water runs. The metal being now in a granular state, is repeatedly subjected to heat in a reverberatory, and each time put into the well. The slag which collects must be removed. The copper after this is kept at a low red heat for two days, then repeatedly fused, and cast into moulds. Lastly, it is put into the refining furnace with a little charcoal, in which it is again fused, and cast. The purest part of it rises to the top, and may be separated by a blow of a hammer.

Copper is obtained from the springs which contain this metal, by putting in pieces of iron. The matter deposited is then fused.

Assaying.—The ores must in the first place be roasted with a gentle heat. After this, it is to be pulverized, and mixed with twice its weight of black flux in a crucible, and exposed to a strong heat of

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a smith's forge for about half an hour. Should the globules of revived metal not readily form a button at the bottom, a little salt thrown in will accomplish it.

The ores of copper present the following varieties:

Native Copper.

Geognostic Situation.—In the veins of primary and secondary rocks.

External Characters.—Color, copper red, tarnished externally, brownish black. Occurs dentritic, capillary, reniform, and amorphous; also crystallized in cubes and octohedrons. Malleable. Specific gravity = 8.5.

Chemical Characters.—Fusible. Soluble in acids.

Composition.—Nearly pure copper.

Sulphuret of Copper.

Geognostic Situation.—Found in almost every kind of repository in all the great classes of rocks; particularly in beds and veins in primary and secondary rocks. It is a valuable ore.

External Characters.—Color, blackish steel-gray, sometimes iridiscent; internally lead-gray. Occurs massive, and in pseudomorphous crystals; also crystallized in long tabular six-sided prisms, and in double six-sided pyramids. Structure, lamellar.

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Tessular. Cleavage easy with brilliant faces. Easily broken into grains. Fracture conchoidal. Specific gravity = 5.

Chemical Characters.—Soluble in hot aquafortis. Fusible.

Distinctive Characters.—*Gray copper* decrepitates under the blowpipe, and is harder. This gives out only the fumes of sulphur.

Composition.—Copper 76.50; sulphur 22; iron 0.50.

Copper Pyrites.

Geognostic Situation.—Same as that of the preceding. It is one of the most abundant and valuable ores of copper.

External Characters.—Color, brass-yellow. Occurs dentritic, stalactical, amorphous, in concretions, and crystallized in tetrahedrons and dodecahedrons. Lustre, metallic. Structure, lamellar. Crystals, small and seldom perfect. Cleavage, tessular. Yields to the knife. Fracture, commonly uneven. Specific gravity = 4.3.

Chemical Characters.—Fusible. Tinges borax green.

Distinctive Characters.—*Iron pyrites* does not tinge borax green. *Native bismuth* is lamellated, and *native gold* is malleable.

Composition.—Copper 40. to 35.5; iron 40. to 33; sulphur 20. to 35.

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Gray Copper.

Geognostic Situation.—Accompanies the other ores of copper.

External Characters.—Color, steel-gray, passing into black. Streak brownish. Occurs amorphous, disseminated, and crystallized in tetrahedrons. Lustre, metallic. Brittle. Crystals small. Specific gravity = 5.

Chemical Characters.—Fusible, but not easily reduced.

Distinctive Characters.—*Specular oxide of iron* is magnetic; arsenical iron is harder, and gives out the fumes of arsenic when heated.

Composition.—Copper 52; iron 23; sulphur 14.

Red Oxide of Copper.

Geognostic Situation.—Associated with the other copper ores.

External Characters.—Color, red. Occurs amorphous and crystallized in octohedrons and cubes. Structure, lamellar. Lustre, metallic adamantine. Fracture, conchoidal and uneven. Translucent. Yields to the knife. Brittle. Specific gravity = 4. to 5.9.

Chemical Characters.—Fusible, and easily reduced. Dissolves in aquafortis with effervescence; in muriatic acid, without.

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Distinctive Characters.—Its chemical characters.

Composition.—Copper from 88.5 to 91; oxygen from 11.5 to 9.

Blue Carbonate of Copper.

Geognostic Situation.—In primary and secondary mountains.

External Characters.—Color, blue. Occurs massive, stalactical, incrusting, disseminated, and crystallized. Fracture, imperfectly foliated, usually presenting broad fibres.

Chemical Characters.—Infusible without a flux; with borax, gives a green glass. Dissolves in aqua-fortis with effervescence.

Distinctive Characters.—Insoluble in water; does not become magnetic under the blowpipe.

Composition.—Oxide of copper 70; carbonic acid 24; water 6.

Tests for Copper.—To a solution of this metal, present a plate of iron, result = metallic copper; potash, result = green precipitate; ammonia, (harts-horn), result = blue color.

Copper *melts* at 1996°; it is ductile, malleable, and tenacious; it is hard, elastic, and sonorous.

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6.—Iron.

Geognostic Situation.—It occurs in primary and secondary rocks.

Extraction.—The ore is first broken into small pieces by the aid of the stamping-mill. (See *Gold.*) After this it is roasted with a strong heat. It is then transferred to the blast-furnace, in which the operation of smelting is conducted. This is a large pyramidal stack, made of brick or hewn stone, from twenty to sixty feet high, having the inside cavity shaped like an egg, with its large end downwards, and lined with fire-brick or stone. Into this is placed alternate layers of charcoal or coke, and of the metallic matter; a quantity of lime is at the same time added as a flux. Before putting these in, however, the furnace must be first heated with coal only for twenty-four hours, and is then charged with the ore, etc., until it is quite full; a strong heat is then excited by bellows. As fast as the materials sink, by the melted metal being drawn out, the charge is renewed at the upper part. The slag rises to the surface and is drawn off by an opening, while the metal collects at the bottom. The latter is conveyed off at intervals, and cast into moulds, and is then known as *pig iron* or *crude iron.* To obtain it still purer, it is broken in pieces and

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kept in fusion in a puddling-furnace, where it is raised to a very high temperature, and frequently stirred with an iron rod. At length the mass swells, emits a blue flame, and gradually becomes stiff and pasty. It is finally raised in a rude ball, and placed under the blows of a large tilt-hammer. It is cut up, and piled or fagoted, and reheated several times, until it is made into tough and fibrous metal. It thus becomes the malleable iron of commerce, under the name of *wrought, forged,* or *bar iron.*

Assaying.—The ore should first be roasted with a strong red heat, as long as any smell arises. After this, two parts of the mineral are to be intimately mixed by trituration with one of fluor spar, one of charcoal, and four of salt, by weight. If the ore contains much stony matter, one part of black flux must be added to the mixture. The whole is then put into a covered crucible, and exposed to a white heat for an hour; after which a button of cast iron will be found at the bottom, which determines the percentage.

The ores from which the iron of commerce is extracted, are:—

Brown Hæmatite.

Geognostic Situation.—Occurs abundantly in primary districts, and sometimes in secondary. It yields the finest kind of iron.

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External Characters.—Color, brown, yellowish, or blackish brown; on the outside resembling black glazed earthenware. Occurs stalactical, tuberous, nodular, and amorphous. Structure, fibrous. Lustre, silky or resinous; yields to the knife. In a variety of this ore the structure is compact; lustre, none; streak, yellowish brown; fracture, conchoidal or earthy.

Red Hæmatite.

Geognostic Situation.—Chiefly in the primary—often in lead mines. It yields the best of iron for drawing and rolling.

External Characters.—Colors, blood-red and dark steel-gray. Occurs massive, and in plates; also reniform, globular, and pulverulent. Fracture, uneven and earthy. Yields easily to the knife. Adheres to the tongue. Specific gravity 4.75.

Chemical Characters.—Infusible, but becomes magnetic.

Composition.—Oxide of iron 90; silex 2; lime 1; water 3.

Specular Oxide of Iron. (Iron Glance.)

Geognostic Situation.—Occurs chiefly in primary mountains, associated with magnetic iron, red hæmatite, quartz, etc.; also in secondary rocks. Affords good malleable iron.

External Characters.—Color, steel-gray, with a

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highly polished surface; often tarnished. Streak, cherry-red. Occurs crystallized in pyramidal octohedrons, pyramidal dodecahedrons, hexahedral tables; also massive, disseminated, in concretions. Structure, lamellar. Lustre, brilliant. Slightly attracted by the magnet. Specific gravity = 5.52.

Chemical Characters.—Infusible. Insoluble in acids.

Distinctive Characters.—Yields a red powder when heated, and becomes magnetic.

Composition.—Iron 69; oxygen 31.

Magnetic Oxide of Iron. (Iron Sand.)

Geognostic Situation.—Occurs imbedded in trap rocks, and called *mountain ore.* Furnishes best bar iron, and yields from fifty to ninety per cent. of the metal.

External Characters.—Color, iron-black. Occurs in minute grains; also in octahedral crystals. Fracture, conchoidal. Strongly magnetic. Powder, black.

Chemical Characters.—Infusible by blowpipe.

Composition.—Oxide of iron 85.50; oxide of titanium 14; oxide of manganese 0.50.

Spathic Iron. (Clay Iron Ore.)

Geognostic Situation.—It occurs in veins in granite, gneiss, mica-slate, clay-slate, and graywacke,

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and in these it is associated with ores of lead, cobalt, silver, but seldom with nickel and bismuth; more frequently with galena, copper ore, iron pyrites, and antimony ore. In other veins it is accompanied with brown, red, and black iron ore, calcareous spar, and quartz. But the most extensive formations of this ore are in carboniferous limestone, in which it is arranged in thick beds. It is also found filling up amygdaloidal cavities in trap rocks. It is excellently suited for steel-making; the black variety affording the best.

External Characters.—Colors, yellow, white, brown, and black. Occurs massive, disseminated, with pyramidal impressions; also in granular distinct concretions—nodular; and crystallized. Structure, foliated or lamellar. Lustre, shining vitreous. Streak, white, or yellowish-brown. Yields to the knife; easily broken. Crystals, usually small, and found in groups. Specific gravity = about 4.

Chemical Characters.—Infusible, blackens and becomes magnetic. Effervesces with muriatic acid. Heated with borax, it makes an olive-green glass.

Distinctive Characters.—From the *earthy minerals*, it is distinguished by its weight. From *other iron ores*, crystalline, foliated cleavage; and from *blende*, by its yielding magnetic iron.

Composition.—Oxide of iron 58; carbonic acid 35; oxide of manganese 4.25; magnesia 0.75; lime 0.5.

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Tests for Iron.—Infusion of galls, when added to iron dissolved in an acid, gives a black precipitate, (*black ink;*) prussiate of potash gives a blue precipitate, (*blue ink.*)

7.—Lead.

The ore which is generally wrought, and from which nearly all the lead of commerce is procured, is the

Sulphuret of Lead. (Galena.)

Geognostic Situation.—Occurs in veins, beds, and imbedded masses, in primary and secondary mountains, but most frequently in the latter, and particularly in limestone. It is commonly associated with the ores of zinc, copper, and iron, and often with those of silver. When it is found in the primary rocks, it is generally in granite. It is also found in alluvial deposites.

Extraction.—The ore is first hand-dressed, then pounded and washed, to free it as much as possible of stony matter. What remains must be removed to a reverberatory furnace, where it is speedily made red hot. In this state it is frequently stirred, and when it begins to become soft, the heat is reduced until the whole of the sulphur is expelled. The fire is then made brisk, by which

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the lead is melted, and collects at the bottom. A little lime must then be thrown in, to thicken the scoria, and the lead is drawn off into moulds; the heat is again applied to the scoria, by which more lead is procured.

When the native salts are found with the galena, they are selected, roasted, and afterwards fused in contact with the fuel, with an addition of lime.

When silver is found in the lead in sufficient quantity to be worked, the latter is heated in a furnace; a current of air being directed on its surface, when melted, by bellows. The silver is then freed from the small portion of lead left, by cupellation. Deducting the silver, the remainder is *litharge.*

Assaying.—Reduce a given weight of the ore to powder, place it on a muffle, and apply heat sufficient, so as on moving the muffle from the fire, the smell of arsenic and sulphur is no longer emitted. The roasting thus done, the ore is to be levigated—mixed with its own weight of black flux, and exposed in a crucible to a strong heat. The lead will be found at the bottom, which on being weighed and compared with the weight of the ore, will show the percentage.

In the roasting of lead ores, care must be taken not to fuse them.

External Characters.—Colors, bluish-gray, lead-gray, and on the outside, blackish-gray. Occurs

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amorphous, reticulated, and crystallized in cubes and octohedrons. Structure, lamellated. Lustre, metallic. Perfectly sectile; soft. Very brittle. Opaque.

Chemical Characters.—When heated, first decrepitates, then emits the smell of sulphur, melting into a globule of lead.

Distinctive Characters.—Blende, molybdena, and graphite are infusible.

Composition.—Lead, sulphur, lime, and silex.

Tests for Lead.—Glauber's salts, and an infusion of galls, give to a solution of this metal a white precipitate.

8.—Tin.

The only ore that is wrought to obtain this metal, is the

Oxide of Tin. (Tinstone.)

Geognostic Situation.—Occurs most commonly in primary rocks, where it is found in veins, traversing granite, gneiss, mica-slate, clay-slate, and porphyry, and is usually associated with chlorite, iron pyrites, topaz, quartz, fluor, &c. The metal extracted from the ore taken from this situation, is called *Block Tin.* It is also found in alluvium and

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drift, and the ore is called *Stream Tin*, from which the metal being extracted, becomes the *Grain Tin* of commerce.

Extraction.—The ore which is procured from the mines is freed from impurities by stamping, (see *Gold*,) after which it is roasted in a reverberatory furnace, which is about seven feet long, five broad, and fifteen inches deep. The usual charge of ore is seven cwt., which yields about two-thirds its weight of tin. The ore is again washed; it is then mixed with one-fifth of its bulk of coal and a portion of slacked lime, and smelted in the furnace for about six hours, at the end of which the metal collects at the bottom, covered with a black scoria. The tin is then drawn off into a shallow pit, in which it is freed from the scoria on its surface. It is then taken out with ladles, and poured into moulds. The metal is afterwards exposed to a gentle heat in a small reverberatory, by which the purest part melts first and is conveyed off.

The stream tin-stone is melted in a different way. The ore in its powdery state is submitted to a stream of water. It is afterwards bruised and passed through wire sieves. It is then blown, with alternate quantities of charcoal, into a blast-furnace, in which being reduced, it escapes through a channel at the bottom into pits; the scoria being removed as it collects, and thrown again into the furnace. The metal is then put into a large iron pot,

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where it is kept melted. In this state pieces of charcoal are thrown in. It is then tried, by removing a quantity in a ladle, and pouring it into the pot. If it appear bright like silver, and of the same consistence throughout, it is pure. After this it is poured into moulds.

Assaying.—Reduce the ore to a coarse powder, wash, and then expose to heat with charcoal till no garlic odor arises. What remains is to be mixed with half its weight of calcined borax, or sawdust, and the same quantity of powdered pitch, and subjected to a strong heat in a crucible lined with charcoal. After the pitch is burnt, give a violent heat for a quarter of an hour, and on withdrawing the crucible, a button of pure tin will be found at the bottom, which shows the percentage.

External Characters.—Colors, brown, black, green, white, red, and yellow. Occurs in crystals, and in masses from the size of grains to that of the fist. Lustre, resinous or adamantine. Streak, grayish-white. Structure, lamellar. Gives sparks with steel. Brittle. Specific gravity = from 6.7 to 7.

Chemical Characters.—Decrepitates, but in powder may be reduced to metallic state on charcoal.

Distinctive Characters.—*Spathic iron* leaves a globule of iron under the blowpipe. *Blende* is infusible, and not so hard.

Composition.—Tin 77.5; oxygen 21.5; oxide of iron 0.25; silex 0.75.

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Test for Tin.—To a solution holding the metal present a plate of iron, result = metallic tin.

9.—Zinc.

Geognostic Situation.—Primary and secondary rocks.

Extraction.—The ore, being hand-dressed to free it from foreign matter, is roasted. The product is then washed, and the heavy part remaining is mixed with one-eighth of its weight of charcoal. The mixture is next reduced to powder in a mill, in which state it is put into the pots to be smelted. These pots resemble oil-jars in shape. Through the bottom of each there passes a tube, the upper end of which terminates by an open mouth near the top of the pot; the lower end goes through the floor of the furnace into water. The pots are filled to the upper end of the tube with the mixture of ore and charcoal, and an intense heat is applied to them by a furnace. As the ore is reduced, the zinc escapes in vapor through the tube into the water, where it is condensed in the form of globules. These are afterwards melted and cast into moulds. To make it still purer, it is again melted, and then well stirred along with sulphur and fat, the former of which combines with the foreign metals, and leaves the zinc nearly pure.

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Assaying.—After being roasted, the ore is mixed with one-half its weight of charcoal-dust, and exposed to a strong heat for one hour in an earthen retort, the mouth of which terminates in water. The metal condensed in the water and neck of the retort, is collected and weighed.

The ores used in metallurgy are—

Blende. (Mock-lead, False-galena, Black-jack.)

Geognostic Situation.—Occurs in veins in primary and secondary rocks, generally associated with galena, with iron and copper. This ore is commonly too widely disseminated in its gangue to make it profitable. It is, however, used after roasting in the preparation of brass.

External Characters.—Colors, yellow, brown, and black. Occurs massive, lamelliform, disseminated, in granular concretions, and crystallized. Lustre, shining and adamantine. Yields to the knife; brittle. Structure, foliated. Specific gravity = 3.7 to 4.

Chemical Characters.—When heated, decrepitates. When thrown into oil of vitriol, it gives the smell of rotten eggs.

Distinctive Characters.—Infusible. Does not tinge borax green.

Composition.—Zinc, sulphur, iron, and silex.

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Calamine.

Geognostic Situation.—Occurs in beds, nests, filling up or lining hollows, in secondary limestone, and conglomerate rock; also in veins, usually along with oxide of iron, and sometimes with galena.

External Characters.—Colors, gray, greenish, or brown yellowish, and sometimes nearly white. Occurs crystallized, compact, amorphous, pseudomorphous, and cupriferous. Yields to the knife. Specific gravity = 3.35 to 4.41.

Chemical Characters.—Infusible. Dissolves with effervescence in muriatic acid or warm aquafortis.

Composition.—Oxide of zinc and carbonic acid.

Red Ore of Zinc.

Geological Situation.—Iron mines; also in limestone.

External Characters.—Color, red. Occurs massive and disseminated. Lustre, shining, by exposure becomes dull. Structure, foliated. Yields to the knife; brittle. Specific gravity = 6.22.

Chemical Characters.—Infusible. Soluble with effervescence in acids.

Distinctive Characters.—Infusibility and weight.

Composition.—Oxide of manganese and oxide of zinc.

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10.—Manganese.

This metal, in its metallic state, has not been converted to any use; but the ore which answers, without any preparation, all the purposes for which the metal is employed, is the

Black Oxide of Manganese.

Geognostic Situation.—Occurs in veins and imbedded masses in primary rocks; frequently found with the ores of iron.

External Characters.—Color, very dark steel-gray. Occurs massive, in fibrous concretions, and crystallized. Lustre, metallic. Streak, black. Fracture, conchoidal and earthy.

Chemical Characters.—Infusible alone, but with borax forms a purple globule.

Composition.—Manganese, oxygen, and water.

11.—Cobalt.

Cobalt is not procured in its metallic state for the purposes of art. The preparations of it in general use are, *zaffree* and *smalt*. The ore from which they are obtained, is

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Arsenical Cobalt.

Geognostic Situation.—Occurs in veins, traversing primary rocks, associated with nickel, bismuth, silver, arsenic, and copper.

External Characters.—Color, silver-white, with a tinge of copper-red. Occurs massive, dentritic, reticulated, stalactical, and crystallized in cubes and octohedrons. Lustre, metallic. Brittle. Fracture, conchoidal. Yields with difficulty to the knife. Specific gravity = 6.33 to 7.30.

Chemical Characters.—In the flame of a candle it emits the garlic odor, and turns black. Melted with borax, gives a blue glass.

Composition.—Cobalt, arsenic, and sulphur.

To prepare Zaffree.—Break the ore with hammers into pieces about the size of a hen's egg. Pound the mineral in stamping-mills, and sift. Wash, and then put into a large flat-bottomed arched furnace, where the flame of the wood is made to play upon it. Stir often. The vapor is conveyed through a long flue, in which it is condensed. When the fumes cease, the ore is removed and reduced to powder, and again exposed to heat. It is then reduced to powder, and sifted. This is the oxide of cobalt. It is, however, commonly adulterated with three times its weight of powdered flints moistened with water.

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To prepare Smalt.—Mix the pure zaffree with equal parts of potashes and sand. Heat it in large pots for ten or twelve hours, and frequently stir. Take it out in ladles, and drop into water. Then pound, sift, and grind.

12.—Nickel.

The ore from which this metal is obtained, is

Arsenical Nickel. (Kupfer, or Copper Nickel.)

Geognostic Situation.—Accompanies cobalt. Secondary rocks.

Extraction.—Roast well the ore. The greener the calx proves, the more it abounds in the metal. Fuse the roasted ore in an open crucible, with twice or thrice its weight of black flux, and the whole cover with salt. Expose it to the strongest heat of a forge fire, and the nickel will be obtained. It then generally contains a little arsenic and cobalt. To free it from the first, re-roast it; and from the second, by pouring ammonia into a saturated solution of the roasted ore in nitric acid. Filter, and the gray powder remaining is the nickel.

External Characters.—Color, copper-red. Tarnishes. Occurs massive, reticulated, and botryoidal. Lustre, metallic. Yields with difficulty to the knife. Specific gravity = 6.60 to 7.70.

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Chemical Characters.—Gives out garlic odor when heated. Forms a green solution in warm aquafortis.

Composition.—Nickel, arsenic, iron, lead, sulphur, and cobalt.

13.—Bismuth.

Geognostic Situation.—Primary rocks, and particularly in quartz, gneiss, and mica-slate, generally associated with cobalt, arsenic, silver, iron pyrites, and galena.

Extraction.—When found native and alone, the metal is fit for use immediately.* Most of the bismuth used in the arts, is obtained in the process for making *smalt* from the ores of cobalt. At the bottom of the crucibles the bismuth, with other metals, is found. Apply a gentle heat, and the bismuth melting first can be poured off.

External Characters.—Color, silver-white, inclining to red. Occurs amorphous, plumose, reticulated, and crystallized. Structure, lamellar. Lustre, metallic. Softer than copper. Tarnishes. Melts at 476°. Specific gravity = 9.

* Sometimes, however, it is necessary to mix it with half its weight of borax and of pounded glass, and subject to heat in a crucible lined with charcoal.

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14.—Arsenic.

Arsenic is not used in the metallic state in the arts; and no mines are wrought for obtaining it. The forms in which it is employed, are

Oxide of Arsenic. (White Arsenic.)

Geognostic Situation.—This is a very rare mineral. It is found chiefly in the primary rocks, with the ores of cobalt, copper, lead, silver, &c.

Extraction.—The white arsenic of commerce is procured by the process of roasting the ores of cobalt, nickel, and iron. These are placed in large cast-iron boxes, to which horizontal flues are closely luted. These are heated by flues from a furnace. When red hot, about 15 lbs. of the ore are thrown in, and when all the arsenic has been driven off another portion of ore is put in, and the process continued for 12 hours, during which time about 150 lbs. of the ore have been used. What is collected in the flues of the boxes is broken off by hammers, freed from any foreign matter adhering to it, and purified by a second sublimation.

External Characters.—Color, white. Occurs earthy, capillary, and investing; also crystallized. Lustre, vitreous. Fracture, conchoidal. Brittle. Specific gravity = 3.7.

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Chemical Characters.—At 380° it sublimes. Heated with charcoal it gives a garlic odor. Soluble in 10 parts of hot water. Poison.

Realgar.

Geognostic Situation.—Occurs most frequently in veins in the primary rocks, less often in secondary; also among volcanic matter.

It may be formed artificially by heating white arsenic, (ratsbane,) with half its weight of sulphur, until the mixture is brought into a state of perfect fusion.

External Characters.—Color, ruby-red. Occurs amorphous, disseminated, in flakes, in concretions, and cry stallized. Lustre, resinous. Streak, orange-yellow. Translucent. Soft; brittle. Becomes electric when rubbed on the sleeve. Specific gravity = 3.3 to 3.4.

Chemical Characters.—Melts easily and burns with a blue flame and white smoke, emitting the smell of garlic and sulphur.

Distinctive Characters.—The *chromate of lead* is much heavier, and tinges borax green. The *red ores of silver and mercury* are heavier and give a red streak.

Composition.—Arsenic 69; sulphur 31.

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Orpiment.

Geognostic Situation.—Secondary and primary rocks.

It may be prepared artificially by fusing together equal parts of white arsenic and sulphur.

External Characters.—Color, lemon-yellow. Occurs reniform, disseminated, and in plates. Lust e, shining. Flexible. Translucent. Sectile. Specific gravity = 3.4 to 3.6.

Chemical Characters.—Burns, emitting the smell of arsenic and sulphur. Becomes electric by friction.

Composition.—Arsenic 57; sulphur 43.

15.—Antimony.

The ore from which the antimony of commerce is obtained, is the

Sulphuret of Antimony.

Geognostic Situation.—Primary and secondary rocks, chiefly in granite, gneiss, and mica-slate, associated with galena, blende, the ores of iron, copper, and arsenic.

Extraction of the metal.—The ore is broken, freed from stony matter, and then put on the hearth of

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a reverberatory furnace, and covered with charcoal. The metal is then melted, while the foreign ingredients float on the surface, and are removed by ladles. The metal is poured into moulds, and forms crude antimony. From this the pure metal is obtained by *scorification*. For this purpose, 8 parts of it are finely powdered, and mixed with 6 of crude tartar and 3 of nitre, and the mixture then thrown in successive portions into a red-hot pot. When the vessel is nearly filled, it is covered, and a strong heat applied for half an hour; the melted mass is then poured into a conical iron vessel, greased in the inside, in which it separates into different layers, the upper consisting of scoria, the lower of antimony in its metallic state.

External Characters, (of the ore.)—Color, lead-gray. Streak, unchanged. Occurs massive, composed of delicate threads or needles, and crystallized. Lustre, splendent. Fracture, fibrous. Yields to the knife; brittle. Specific gravity = 4. to 4.80.

Chemical Characters.—Melts in a candle-flame. Before the blowpipe emits the smell of sulphur, and sublimes.

Composition.—Antimony 74; sulphur 26.

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Anthracite. (Blind or Glance Coal.)

Geognostic Situation.—Occurs in imbedded masses, beds, and veins, in primary and secondary rocks, often in graywacke, sandstone, trap-rocks, slate, &c. It is also called *stone-coal.*

Black or Bituminous Coal.

Geognostic Situation.—Chiefly in the secondary series, sometimes in clay, sandstone, and limestone. Its varieties are called *slate, foliated, cannel,* and *coarse coal.*

Lignite. (Brown Coal.)

Geognostic Situation.—Chiefly occurs in secondary rocks; also in alluvium. Its other names are, *bituminous wood, earthy coal, alum earth, jet and moor coal.*

Rock Salt.

Geognostic Situation.—Secondary strata; often found associated with gypsum, clay, marl, &c.

Limestone.

Geognostic Situation.—Almost every rock below drift. The best marble occurs in the upper part of the primary, and lower part of the secondary rocks.

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Gypsum.

Geognostic Situation.—New red sandstone, and other secondary rocks.

Clay.

Geognostic Situation.—Secondary rocks. *Porcelain* clay is found in connection with granite.

Plumbago.

Geognostic Situation.—In the coal formation; also in clay-slate. It is often called *graphite* or *black-lead.*

Precious Stones.

Geognostic Situation.—Nearly all of them, as the *sapphire, emerald, spinel, chrysoberyl, chrysoprase, topaz, iolite, garnet, tourmaline, chalcedony, amethyst,* &c., are always in the primary rocks. *Quartz* in the form of *rock crystal, carnelian, cacholong, sardonyx, jasper,* &c., is found often in secondary strata, especially in the trap rocks. The diamond is generally found in drift.

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Unstratified. Stratified.

Granite.

Gneiss.

Mica Schist.

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SECTION OF EXISTING ARRANGEMENT OF ROCKS.

In the above section, the UNSTRATIFIED ROCKS appear in hills and irregular disrupting masses, from the older granite to the active volcano; while the STRATIFIED occur in their regular order of succession. The *Primary* slope from the side of a lofty granitic mountain, at a high angle, and in bent or contorted strata; the *Transition* lie between the ranges of less elevated mountains; the *Secondary* occupy a still less elevated position, the Mountain Limestone being raised up on the hill-side, with the Coal Beds thrown into basin-shaped hollows, or broken up by faults, and the Magnesian Limestone and Chalk rising up into slight eminences; the *Tertiary*, in basin-shaped strata; and the *Superficial Accumulations* occur either as sandy downs by the seashore, or as diluvium, with bowlders overlying the earlier formations. The student will perceive how the Tertiary strata are said to be above the Coal Measures, though they do not overlie them; and how the Coal Beds are above the Transition rocks, though removed from each other by the wide extent of country. The lowest strata being formed first, he will also understand why coal is said to be of more recent origin than clay-slate, and chalk younger than coal.

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A TABULAR VIEW

OF THE ROCKS OF THE UNITED STATES.

Alluvium. Bog ore, clay iron ore, manganese, peat, marl, &c.

Drift. Gold, copper, lead, iron, barytes, &c.

Tertiary. Brown hematite, manganese, iron pyrites, &c.

Secondary.

- New Red Sandstone. Copper, iron, lead, zinc, coal, gypsum, salt, &c.
- Green Sand. Iron, copper, manganese, gypsum, clay, &c.
- Coal Measures. Iron ore in large quantities, &c.
- Millstone Grit. / Old Red Sandstone. / Graywacke. — Iron, copper, anthracite, plumbago, &c.
- Mountain Limestone. / Argillaceous Slate. — Ores of lead, zinc, copper, gold, &c.

Primary.

- Limestone. Brown hematite, magnetic oxide of iron, iron pyrites, copper, &c.
- Quartz Rock. Brown hematite, iron pyrites, quartz crystals, &c.
- Mica Slate. Manganese, iron, lead, zinc, sulphur, anthracite, &c.
- Talcose Slate. Gold, blue and green carbonate of copper, iron, manganese, arsenic, &c.
- Serpentine. Magnetic iron, soapstone, quartz, &c.
- Hornblende Slate. Arsenical cobalt, iron ore, iron pyrites, &c.
- Gneiss. Ores of iron, copper, plumbago, alum, soapstone, &c.
- Greenstone. Ores of iron and copper, quartz crystals, &c.
- Porphyry. Gold, specular iron.
- Sienite. Lead, zinc, copper, barytes, fluor, &c.
- Granite. Ores of copper, iron, lead, zinc, tin, manganese, fluor, sulphur, &c.

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ALLOYS.

Queen's metal.

Melt together 4½ lbs. of tin, ½ lb. of bismuth, ½ lb. of antimony, and ½ lb. of lead. *Another.*—Tin 100 lbs., regulus of antimony 8 lbs., 1 lb. of bismuth, and 4 of copper.

Tombac.

Copper 16 lbs., tin 1 lb., and zinc 1 lb. Melt together.

Red tombac.

Melt 5½ lbs. of copper with ½ lb. of zinc.

White tombac.

Put copper with arsenic in a crucible, cover with salt, and melt.

Mosaic gold—Ormolu.

Melt equal parts of copper and zinc at the lowest temperature possible, adding by degrees a little zinc.

Common pewter.

Tin 7 lbs., lead 1 lb., copper 6 oz., and zinc 2 oz.

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Best pewter.

Tin 100 parts, and regulus of antimony 17 parts.

Hard pewter.

Tin 17 lbs., regulus of antimony 1 lb., and copper 4 oz.

Flute-key valves.

Lead 4 oz., antimony 2 oz.

Common solder.

Lead 2 lbs., and tin 1 lb.

Hard solder.

Copper 2 lbs., and tin 1 lb.

Soft solder.

Tin 2 lbs., and lead 1 lb.

Type metal.

Lead 10 lbs., antimony 2 lbs.

Stereotype plates.

Lead 9 lbs., antimony 2 lbs., and bismuth 1 lb.
Another.—Lead 8 lbs., antimony 2 lbs., and tin $\frac{1}{8}$ lb.

White metal.

Lead 10 oz., bismuth 6 oz., regulus of antimony 4 drachms.

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Hard white metal.

Brass 1 lb., spelter 1½ oz., tin ½ oz.

Tutenag.

Tin 4 lbs., and bismuth 1 lb.

Fusible alloy.

Bismuth 8 oz., lead 5 oz., and 3 oz. of tin. *Another.*—Zinc 1 oz., bismuth 1 oz., lead 1 oz.

Metallic injection.

Melt equal parts of bismuth, lead, and tin, and some quicksilver.

Amalgam for electric cushion.

Melt zinc 2 drachms and 1 of tin, then add 5 drachms of quicksilver.

For varnishing figures.

Tin ½ oz., bismuth ½ oz., mercury ½ oz. Melt and mix with white of egg.

Bath metal.

Brass 2 lbs., and 9 oz. of spelter.

Brass.

Copper 4½ lbs., when melted add 1½ lb. of zinc.

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Pinchbeck.

Copper 5 oz., zinc 1 oz. *Another.*—Brass 1 oz., copper 1½ or 2 oz. Melt under a coat of charcoal-dust.

Blanched copper.

Fuse 8 oz. of copper and ½ oz. of neutral arsenical salt, with a flux made of calcined borax, charcoal-dust, and powdered glass.

Bell metal.

Copper 6 parts and tin 2 parts. *Another.*—Copper 5 parts to 1 of tin.

Gun metal.

Bristol brass 112 lbs., spelter 14 lbs., and block tin 7 lbs. *Another.*—Copper 9 lbs., and tin 1 lb.

Speculum metal.

Copper 7 lbs., zinc 3 lbs., and 4 lbs. of tin.

Bronze.

Copper 7 lbs., zinc 3 lbs., and tin 2 lbs.

Prince's metal.

Copper 3 oz., zinc 1 oz.; or, brass 16 oz., zinc 2 oz.; or, copper 2 oz., zinc 1 oz.

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Mock platinum.

Brass 8 oz., and spelter 5 oz.

Gilding metal.

Copper 4 parts, Bristol brass 1 part, and 14 oz. of tin to every lb. of copper.

For common jewelry.

Copper 3 lbs., Bristol brass 1 lb., and 12 oz. of tin.

Yellow dipping metal.

Cheadle brass 2 lbs., copper 1 lb., tin $\frac{1}{4}$ oz., and a little Bristol brass. *Another.*—Copper 1 lb., spelter 5 oz.

Mock silver.

Copper 1 lb., and tin $\frac{3}{4}$ oz.

Tutania or Britannia metal.

Plate brass 4 oz., tin 4 oz., bismuth 4 oz., regulus of antimony 3 oz. *Another.*—Shruff brass 8 oz., tin 10 lbs., and 2 lbs. of regulus of antimony.

German tutania.

Copper 2 drachms, regulus of antimony 1 oz., tin 12 oz.

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Spanish tutania.

Scrap iron or steel 8 oz., heat to whiteness, add 1 lb. of antimony with 3 oz. of nitre. Afterwards add 1 lb. of tin with a little arsenic.

Engestroom tutania.

Copper 4 parts, regulus of antimony 8 parts, bismuth 1 part, tin 100 parts.

Kustitien's metal for tinning.

Malleable iron 1 lb., heat to whiteness, add regulus of antimony 5 oz., and Molucca tin 24 lbs.

Solder for steel joints.

Silver 19 pennyweights, copper 1 ditto, and brass 2 ditto. Melt these under a coat of charcoal-dust.

Silver solder for jewellers.

Silver 19 pennyweights, copper 1 do., and brass 10 do.

Silver solder for plating.

Brass 10 pennyweights, and silver 1 ounce.

Gold silver.

Gold 12 pennyweights, silver 2 do., copper 4 do.

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Elastic platinum.

To 7½ drachms of melted gold add ½ drachm of platinum.

Ring gold.

Spanish copper 6 pennyweights and 12 grains, silver 88 grains, and gold coin 1 oz. 5 pennyweights.

Manheim gold—similor.

Copper 3½ oz., brass 1½ oz., pure tin 15 grains.

White Copper.

Copper 40.4, zinc 25.4, nickel 31.6, and iron 2.6.

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GLOSSARY.

ACICULAR. In the shape of a needle.
Acute. Sharp at the end.
Adamantine. Resembling the diamond.
Alluvial. Relating to Alluvium. See *Introduction.*
Amorphous. Devoid of regular form.
Amygdaloid. A trap rock which is porous and spongy, with rounded cavities.

BARYTES. Heavy spar; sulphate of baryta.
Bituminous. Containing bitumen or mineral pitch.
Black flux. Tartar deflagrated with half its weight of nitre.
Blowpipe. An instrument by which a current of air is blown through flame, directed upon any substance, to fuse it.
Botryoidal. Resembling a bunch of grapes.

CAPILLARY. Hair-like; long and slender.
Clay-slate. A mineral found in the primary and secondary rocks. Colors, reddish, bluish, or greenish brown. Occurs massive. Structure, slaty. Lustre glimmering. Yields to the knife.
Cohesion. The act or power of sticking together.

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Cleavage. Capability of being divided in fixed directions.

Cube. A figure having six equal sides.

Cupel. A small cup, made of bone-ashes, and having a small depression on its upper surface, into which the substance is placed.

Conchoidal. Having bent elevations or depressions, in form like the shell of a fish.

Concretion. A small mass; a lump; a clot.

Carboniferous. Containing coal. *C. Limestone.*—A gray, compact limestone, found in secondary rocks, traversed by veins of spar. Often full of organic remains. Also called *mountain* or *metalliferous* limestone.

Chlorite. A soft, green, scaly mineral, slightly soapy. It occurs in primary rocks.

Calcined. Reduced to powder by heat.

Conglomerate. Rocks composed of rounded masses, pebbles, and gravel cemented together. Often called *Pudding-stone.*

Cupriferous. Containing copper.

Conical. Round, and shaped like a sugar-loaf.

Disseminated. Scattered; occurring in portions less in size than a hazel-nut.

Deposite. That which is laid or thrown down.

Debris. Masses of rock, etc., detached from the summit and sides of a mountain, and piled up below.

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Dentritic. Appearing like a tree.

Dodecahedron. A figure of 12 equal sides.

Ductile. That may be drawn out into wires.

Dentiform. Like a tooth in form.

Decrepitate. To crackle like salt when roasted.

Deflagration. Rapid burning, attended with flame and vapor.

Drift. Earth and rocks, which have been drifted by water, and deposited over a country while submerged. The surface is often scooped out into deep basin-shaped depressions and elevations. Scattered through it are large rounded rocks, called *bowlders.* Platinum, gold, and diamonds are explored almost exclusively in this formation. It lies under *alluvium* and over *secondary* rocks.

Effervescence. Boiling; bubbling.

Fusible. That may be melted. To *fuse* is to melt.

Fibres. Threads. *Fibrous.*—Presenting fine threads or slender lines.

Foliated. Consisting of plates or thin layers.

Fissure. A cleft; a chasm; an opening running lengthwise.

Fracture. The manner in which a mineral breaks.

Fluor, Fluor Spar. A mineral much used for ornamental vessels; found mostly in metallic veins in primary rocks.

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Flux. A substance used to promote the melting of metals.

GLOBULAR. Round; like a ball.

Geognostic. Pertaining to a knowledge of the structure of the earth. *G. Situation.*—Position or locality in the earth.

Gneiss. A stratified primary rock, of a striped aspect. It is rich in metallic ores.

Granular. Consisting of grains.

Granite. An unstratified primary rock. Colors, gray, grayish white, and flesh red. It is the lowest rock.

Graywacke. A grit-rock or sandstone, composed of rounded pebbles and sand united together. Occurs in secondary rocks.

HEXAHEDRAL. Having six equal sides.

Hornstone. An impure variety of flint. Color, grayish or yellowish white. Found in primary mountains.

Hackly. Having short, fine, and sharp points on the surface.

Hornblende. A mineral of a dark-green or black color. Hornblende slate occurs in primary rocks.

INFUSIBLE. Not fusible.

Infusion. Steeping in water or liquor.

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Inclination. Leaning; deviation from an upright position.

Iridiscent. Like a rainbow.

Intumescence. A swelling, enlarging.

Iron pyrites. A mineral of a yellow color; lustre, brilliant. Hard and brittle. Appropriately denominated *fools' gold.*

Investing. Covering; coating.

LEVIGATE. To rub or grind to a fine powder.

Lamina, -næ. A thin scale; a layer or coat.

Lamelliform. Having the form of a plate or scale.

Lias. A kind of limestone, occurring in flat, horizontal strata. Found in secondary rocks.

Lamellated. Composed of, or covered with, thin plates.

Lute. A composition of clay or other matter, used for stopping the joining or seam of vessels, so as to be air-tight.

MAGNETIC. Possessing the properties of the lodestone; attractive; having the power of drawing or lifting iron-filings.

Mica-slate. A stratified rock, one of the most common of the primary class. Generally it is capable of being split. It is extensively used for flagging the sidewalks of cities.

Muffle. An oven-shaped vessel, made of earthenware, flat below and arched above, open at one

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end and shut at the other, and at the sides, except where it is perforated by small holes.

Malleable. That may be drawn out and enlarged by beating.

Membranous. Consisting of thin parts, formed by fibres interwoven like net-work, serving as covers.

Marl. An earth or clay, usually in fine powder, confined to the alluvial and tertiary strata. Effervesces on the application of an acid. Often used as a manure.

Massive. In mass; of irregular form.

NEUTRALIZE. To combine substances in such proportions that the compound will not exhibit the properties of either.

Nodular. Presenting irregularly globular elevations.

New Red Sandstone. The group of rocks immediately above the coal measures, or strata. Its usual color is brick-red. Often occurs colored in stripes and spots. It contains occasional beds of gypsum and rock-salt.

Nest. A collected mass of any ore or mineral in a rock.

OBLONG. Longer than broad.

Outcrop. The coming out of a rock to the surface of the ground.

Oxide. A combination of oxygen with another body; rust.

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Oxygen. The vital part of the atmosphere.
Octohedron. A solid having eight equal sides.
Opaque. Not transparent.

PRISM. A solid whose ends are any equal plane figure, and whose sides are oblong.
Pulverulent. Dusty; consisting of powder.
Pyramid. A solid whose sides have one common point or top.
Primary, or *Primitive Rocks.* The group of rocks lowest in order. They consist of clay-slate, quartz rock, hornblende-slate, talcose-slate, serpentine, limestone, mica-slate, gneiss, and granite. They are irregularly crystallized, collected without a cement, and contain no animal relics. They lie below the secondary strata.
Porphyry. An unstratified rock, in which are imbedded crystals. It is either red, purple, or green. Found in the primary.
Plumose. Resembling feathers.

QUARTZ. Pure flint, occurring in glassy crystals. Rock-crystal, is a variety. Abounds in all rocks.

REDUCED. Separated from foreign substances.
Reniform. Kidney-shaped.
Right Angle. A corner formed when a perpendicular line falls on a horizontal one.

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Reciprocating. Backward and forward, or up and down.

Rhomboidal. Having the shape of a four-sided figure, whose sides are equal, but corners unequal.

Reverberatory. A furnace with a kind of dome that drives back the flame upon a vessel placed within it, so as to surround it.

Ramose. Full of branches.

Reticulated. Resembling net-work.

Regulus. The pure metal.

Schistose. Slaty.

Sulphate of Barytes. Heavy spar; a mineral.

Stratified. Arranged in layers.

Shaft. A long, narrow opening into a mine.

Secondary Rocks. Those situated above the primary and below the tertiary. They are mostly made up of sand, clay, and pebbles cemented together, and contain a great many organic remains. They consist chiefly of chalk, green sand, clay, limestone, marl, red sandstone, sandstone, coal, carboniferous limestone, &c.

Serpentine. A mineral, found in primary limestone, gneiss, and mica-slate. Colors, green, yellow, brown, and gray. Receives a high polish. Soapy to the touch. Yields to the knife.

Schist. A slaty rock.

Specific gravity. Weight compared with water.

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Streak. Color a mineral presents when scratched.
Scoria. Dross; rejected matter; scum; slag.
Spangle. Any thing sparkling and brilliant.
Shale. A fine-grained, slaty rock.
Stalactical. Resembling an icicle.
Sectile. Being cut with a knife, the separated particles do not fly off, but remain.
Splendent. Shining; glossy.
Spar. Any crystallized earthy mineral, splendent.
Sublimation. Changing a solid into a state of vapor by heat, and then bringing it again to a solid by cold.

TALCOSE-SLATE. A primary rock, soapy to the touch.
Tessular. Related to the cube.
Tenacious. Sticky; adhesive.
Translucent. Clear; letting light pass through.
Tabular. Having the form of plates or laminæ.
Tertiary Rocks. Those lying above the secondary and below drift, consisting of sandstones, clay beds, limestones, green sand, gypsum, rock-salt, lignite, &c., with animal relics.
Transition Rocks. The lowest uncrystalline stratified rocks.
Trap. An unstratified rock among the primary, of a greenish-black or grayish color, and often arranged like stairs.
Triturate. To rub or grind to a fine powder.
Tuberous. Knobbed.

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VITREOUS. Glassy.
Volatile. Apt to go off in vapor.

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